DTU Library

Antenna standards and laboratories in Europe

Lemanczyk, Jerzy

Published in:
I E E E Transactions on Instrumentation and Measurement

Link to article, DOI:
10.1109/19.377849

Publication date:
1995

Document Version
Publisher's PDF, also known as Version of record

Antenna Standards and Laboratories in Europe

Jerzy Lemanczyk

Abstract— **This paper sets out to present an overview of antenna standards and laboratories within Europe. In this context, Europe is limited geographically to the member nations of the European Union (EU), formerly the European Community, and the European Space Agency (ESA). In addition to these two organizations, there exists several organs within Europe whose aims are to define, coordinate and implement standards, laboratory certification, multilateral acceptance of testing and calibration as well as international acceptance of the same. These include ETSI, the European Telecommunications Standards Institute and EAL, the European Accreditation of Laboratories, which deals with the practical aspects of laboratory accreditation and international cooperation. ESA, through the Electromagnetics Division of ESTEC, has been active in not only defining the need for European sourced antenna gain standards, but has embarked on a project of antenna range validation as well as defining standardization of validation procedures to better monitor and improve the performance of antenna test laboratories working on ESA projects.**

I. Introduction

THE term antenna standards will be used here to denote antennas calibrated for use in free field antenna and EMC measurements. In essence, the calibration of antennas for either application is the same problem; however, there are differences which argue for them being kept as separate entities. Whereas antenna engineers need precise knowledge of parameters as gain and polarization, the EMC engineer is more interested in absolute field strengths as exemplified by the rather obtuse antenna factor definition. EMC work tends to be in the lower frequency ranges, normally below 1 GHz, with low gain antennas being used while antenna engineers would like to have a standard whose gain is as close as possible to that of the antenna whose gain they wish to determine.

Both disciplines require the use of accurately calibrated reference antennas be they monopoles, biconics or standard gain horns. Thus arise the questions as to what constitutes a calibrated reference antenna, by what authority can a laboratory call itself a standards laboratory, what definitions are to be applied in defining the parameters to be calibrated, why are standards laboratories needed at all and lastly, once a standard is available, no matter how it is defined or arrived at, how can one be assured that it will be applied correctly; a poor measurement is a poor measurement, the presence of an accurately calibrated standard antenna notwithstanding.

The implications of these questions are both technical and political. In the sections to follow, the need for standards from a European perspective will be addressed, followed by a brief presentation of what the author believes to be the most important technical and political organizations involved with the definition and application of standards. It will be seen thereafter that in fact there are few primary standards facilities in Europe although there is a great number of reference laboratories, that is laboratories whose measurements are traceable to primary standards laboratories. In the field of antenna metrology, no other European laboratory has the same general acceptance as that of the National Physical Laboratory in the United Kingdom.

ESA has always stressed the need for European sourced gain standards to be made available to ESA projects which resulted in a series of standard gain horn antennas currently covering the frequency range 1.7 GHz to 40.0 GHz being housed at the Technical University of Denmark (TUD). These horn antennas are calibrated and sent out at ESA's request.

To conclude this expose, a new project initiated by the European Space Agency (ESA) in cooperation with the Technical University of Denmark (TUD) will be presented. The project addresses the last question raised above with respect to the quality of antenna measurements in general and especially with regard to ESA projects. A number of pilot intercomparison measurements between several antenna measurement laboratories were carried out in the 1980's which demonstrated the need and usefulness of the effort and resulted in a formalized project which has as a goal not only a set of suitable test objects, but the definition of a standardized intercomparison procedure for antenna range validation for ESA projects as well.

II. The Need for Standards

The acceptance of a measurement result is dependent on a number of factors, not the least among which is knowledge of and trust in the laboratory carrying out the measurement. The more trust one has in a laboratory and its practices, the less is the requirement for a third party controlling authority, that is laboratory accreditation. An additional aspect of laboratory accreditation however is not so much technical as it is political; the breaking down of technical trade barriers. This is especially true in Europe, as the EU is actively engaged in the realization of a single open market.

To break down these technical trade barriers, the mutual acceptance of standards and testing laboratories is required. Many products require acceptance and certification testing for each individual European market. This is both costly and time consuming and at worst, can discourage or even prevent entry of a product into one market while available in another. To achieve the open market requires that testing carried out for one market be valid for all markets. This can only be the result

Manuscript received July 1, 1994; revised October 15, 1994.

The author is with the Electromagnetics Institute, Technical University of Denmark, DK-2800 Lyngby, Denmark.

IEEE Log Number 9409892.

0018-9456/95$04.00 © 1995 IEEE

of mutually agreed upon technical standards and procedures by which laboratories are accredited thus, allaying any doubt about the competence or acceptability of a test carried out in a country other than one's own.

These administrative requirements are being addressed by the EU which has mandated CEN/CENELEC, the joint European Standards Institute, to produce the rules and guidelines for the establishment, operation and maintenance of laboratory accreditation as well as accreditation authorities. This resulted in a series of European Norms, the most important of which here are EN45001, General criteria for the operation and testing of laboratories, EN45002, General criteria for the assessment of testing laboratories and EN45003, General criteria for laboratory accreditation bodies.

III. European Organization

The needs in the previous section must be addressed from two sides. One is the need for the common language, that is, standards to which all parties can agree. In this respect, perhaps the most important organization on the technical side for antenna metrology in Europe is the European Telecommunications Standards Institute, ETSI, which is a nonprofit open organization that began under the auspices of the European Post and Telegraph cooperation CEPT. This has since been expanded to include members from all the states of the EU and the European Free Trade Association, EFTA. This open forum has, at present,.345 members from 28 countries representing tele- administrations, operators, manufacturers, suppliers and users of telecommunication services in Europe.

The main goal of ETSI is to harmonize standards within their areas of jurisdiction. It also seeks to promote worldwide standardization whenever possible thus requiring interaction with nonexclusive European organizations. The ETSI technical standards result from the work of 11 Technical Committees with approximately 60 Technical Subcommittees and more than 140 Working Groups comprised of over 2000 technical experts. As an example for antenna testing, the EU has adopted ETSI Standards for satellite earth stations exemplified by the recent issue of two new draft standards DE/SES-02008, Satellite Earth Stations and Systems (SES) Test Specification, Very Small Aperture Terminals 11/12/14 GHz frequency bands and DE/SES-04011, Satellite Earth Stations and Systems (SES) Test Specificaiton, Television Receive Only (TVRO) 11/12 GHz frequency bands.

On the accreditation side, to ensure proper application of these standards, the EU has endorsed the multilateral organizations which have emerged whose goals are not only to build up mutual confidence between each countries services but also, to work towards mutual recognition and acceptance of calibrations. The process of organization and cooperation is in a state of flux as the EU continues to work towards an open market.

The organizations which exist to work towards the mutual cooperation and acceptance of metrology and testing services are the Western European Calibration Cooperation, WECC and the Western European Laboratory Accreditation Cooperation, WELAC. In June, 1994, the European Accreditation of Laboratories, EAL, will have been formed which is a merger of WECC and WELAC. However it is practical at this point to treat them separately.

TABLE I
European States Cooperating with WECC and WELAC

COUNTRY	WECC	WELAC
Austria	2	
Belgium	2	
Denmark	1	1
Finland	1	1
France	1	1
Germany	1	
Greece	2	
Iceland	2	
Ireland	1	1
Italy	1	1
The Netherlands	1	1
Norway	1	1
Portugal	2	
Spain	2	1
Sweden	1	1
Switzerland	1	1
United Kingdom	1	1

As mentioned, WECC exists to maintain confidence between accreditation bodies and on the basis of multilateral agreements, to achieve mutual acceptance of certificates issued by accredited laboratories. This would mean that a signatory body would be bound by agreement to recognize a calibration certificate issued by a laboratory in another country party to the agreement even though it may itself have a competent laboratory to carry out a similar calibration. This cooperation thus helps in the removal of the technical trade barriers mentioned in the previous section.

The WECC also is a channel of information between the member states' accreditation bodies to maintain confidence as well as the exchange of know how. The common bases for this are EUROMET, the European measurement standards cooperation, which seeks to ensure a common metrological basis for the calibration activities of the WECC and a series of norms including EN45001, EN45002 and EN45003 mentioned above. In addition, the WECC produces its own set of technical documents such as WEC Doc. 19-1990, Guidelines for the Expression of Uncertainty of Measurements in Calibrations.

WELAC is also a multilateral collaboration between national accreditation bodies with an emphasis on the mutual technical equivalence and acceptance of each others reference and testing laboratories.

In Table I, the current configuration of European states which cooperate with or have signed multilateral agreements under both the WECC and WELAC is shown.

IV. European Laboratories

All the national accreditation authorities under the WECC mentioned in the previous section had been contacted with respect to antenna metrology. The results are presented in Table II. It can be seen that accredited calibration laboratories

TABLE II
OVERVIEW OF ACCREDITED EUROPEAN CALIBRATION LABORATORIES

Country	Laboratory	EMC	Antennas
Austria	Antenna Research Centre Seibersdorf	20m x 17m wire mesh ground plane (ANSI C63.5) 10 KHz - 1000 MHz	
France	LCIE - Laboratoire Central des Industries Electroniques	Ground plane 30 MHz - 1000 MHz	Anechoic chamber 1.5 GHz - 15 GHz
Netherlands	NMi-Van Swinden Laboratorium	Crawford type TEM cells 10 KHz - 750 MHz 20m x 17m open ground plane 30 MHz- 1000 MHz Semi open anechoic chamber for f> 1.5 GHz	Semi open anechoic chamber 4 GHz - 14 GHz
United Kingdom	National Physical Laboratory	60m x 30m welded steel ground plane 20 MHz - 5 GHz TEM cell 1kHz - 4 GHz	Anechoic extrapolation range 1 GHz - 46 GHz, Currently being extended to 100 GHz Planar near field range under construction (4m x 3m) - to operale to 60 GHz

in the area of antenna metrology are few in number in Europe. The uniform response from those authorities which did not have an accredited laboratory under their jurisdiction was that requests for calibration would be directed to NPL in the UK. It was also indicated by the Physikalisch-Technische Bundesanstalt, PTB, Germany, that they were in the process of establishing a primary calibration service. Table II is organized in such a way as to indicate which states have calibration services. These are divided into either EMC or Antenna services and in each case, information about the available facilities and services is presented.

As mentioned in the Introduction, ESA maintains a set of standard gain horns at TUD which can be made available to ESA projects. These are accepted by ESA as primary standards and as result, TUD has carried out several requests for the calibration of customer owned gain standards as well as probe antennas for near field measurement systems; TUD does not have any formal accreditation.

It is also true that the American Institute of Standards and Technology, NIST, performs calibration functions for European industry in the area of antennas.

V. THE VAST PROGRAM

The European Space Agency on the other hand has very specific requirements with respect to antenna measurement standards and the qualification of antenna testing laboratories which carry out work under contract for them. The need for precise and accurate antenna measurements was already defined bu ESA in the early 1970's with feasibility studies into spherical near field antenna measurements being carried out at The Marconi Research Centre, UK and later at the Electromagnetics Institute (EMI) of the Technical University of Denmark (TUD). ESA concluded that near field measurements were the solution to the need for precise and accurate antenna measurements. EMI was able to make a substantial contribution in this direction as the theoretical basis for spherical near field measurements had already been formulated there in the late 1960's.

From this work evolved the TUD-ESA Spherical Near Field Antenna Test Facility, which since 1980 has been providing ESA contractors with calibrated standard gain horn antennas.

TABLE III
LABORATORIES THAT HAVE PARTICIPATED IN AN ESA SPONSORED ANTENNA RANGE IN INTERCOMPARISON

LABORATORY	TYPE	TEST OBJECT
British Aerospace, United Kingdom	Cylindrical Near Field	MBB elliptical offset antenna - 12.0 GHz
CASA, Spain	Spherical Near Field	ERS-1 SAR Breadboard - 5.3 GHz
DASA (MBB), Germany	Cylindrical Near Field	MBB elliptical offset antenna - 12.0 GHz
EMI, TUD, Denmark	Spherical near Field	MBB elliptical offset antenna - 12.0 GHz ERS-1 SAR Breadboard - 5.3 GHz
ESTEC, The Netherlands	Dual Cylindrical Compact Range	MBB elliptical offset antenna - 12.0 GHz ERS-1 SAR Breadboard - 5.3 GHz
ETSIT, Spain	Spherical Near Field	MBB elliptical offset antenna - 12.0 GHz
Matra-Marconi, United Kingdom	Spherical Near Field	MBB elliptical offset antenna - 12.0 GHz
RYMSA	Outdoor far field	MBB elliptical offset antenna - 12.0 GHz
Saab-Ericsson Space, Sweden	Spherical Near Field Planar Near Field	ERS-1 SAR Breadboard - 5.3 GHz
THE, The Netherlands	Dual Cylindrical Compact Range	MBB elliptical offset antenna - 12.0 GHz

Of note, is the existence of this facility is largely unknown to the EU and other organs mentioned above and thus operates outside of their scope. ESA accepted standard gain horns calibrated at TUD as being primary standards to be used in antenna measurements. Due to this acceptance by ESA, other European companies have had their own standards calibrated at TUD, including probes for near field antenna test ranges.

In the mid 1980's, TUD became involved with antenna range intercomparisons in support of on going ESA antenna measurement programs; ESA had defined the need for the qualification of antenna test ranges being used to carry out antenna measurements for their programs. A number of intercomparisons have been carried out over the years with TUD responsible for obtaining data from the participating laboratories, carrying out a control measurement on the test antenna and executing the comparison. In Table III is an overview of all the laboratories which have participated in an ESA sponsored intercomparison to date in antenna measurements. As can be seen, measurements were carried out on two different antennas, one operating at 5.3 GHz and the other at 12.0 GHz. The former antenna is a one-square meter slotted waveguide array which is a breadboard model of one of the ten panels which make up the ERS-1 and ERS-2 SAR antenna. The latter is an offset fed elliptical reflector antenna made available for the intercomparisons by MBB of Munich, Germany. While both antennas were good electrical test objects, they did exhibit shortcomings with regard to this particular application.

The problems were with the mechanical stability and rigidity of the antennas themselves as well as the lack of a well defined coordinate system, now alleviated, on the ERS-1 Breadboard. The MBB antenna was not rigid enough and lack of care in mounting could alter the reflector/feed geometry. To illustrate this, Fig. 1 shows the –6 dB contour relative to peak of four independent measurements carried out on the MBB antenna, two at TUD, one at Matra Marconi and one at British Aerospace. Because of these problems with mechanical stability and coordinate system definitions, it is not possible to say which of the four results is the most correct. Thus, the need became apparent for a specially designed test antenna for intercomparison purposes.

Thus, the collaborative effort between ESA and TUD is now proceeding on two parallel tracks. One is the definition

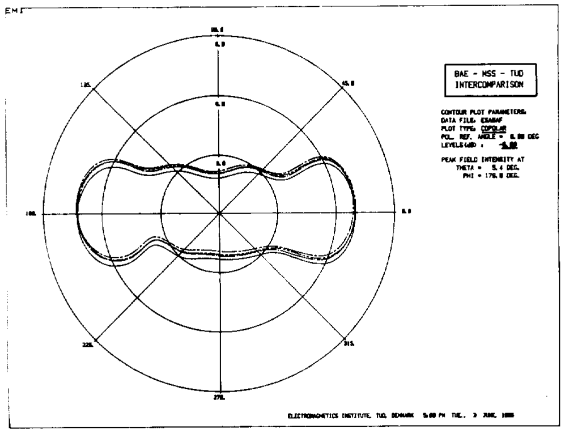

Fig. 1. Four –6 dB relative to peak contours of the MBB antenna measured twice at TUD, once at Matra Marconi and once at British Aerospace. The plot is in the range $\theta < 9^\circ$.

and procurement of suitable antennas to be used in an antenna test range qualification; hence, the emergence of the ESA Validation Standard (VAST) antennas. The second track is the standardization of the validation procedure itself.

The most important properties of the antenna are mechanical stability and rigidity. The first antenna to be designed and fabricated has a nominal operating frequency of 12 GHz and has been dubbed the VAST-12. Over the antenna's operating temperature range 0 to 40°C, the combined effects of temperature and gravitational deformation must not alter a sidelobe level –20 dB relative to peak by more than ± 0.01 dB. The antenna, shown in Fig. 2, was fabricated using light weight carbon fiber/foam sandwich in a box construction to achieve the specified rigidity. A precision mirror cube mounted at the top of the reflector provides an unambiguous coordinate system definition for the presentation of results. The reflector itself, also a carbon fiber/foam sandwich construction, is shaped to provide an elliptical mainbeam, posing an extra challenge to antenna measurement facilities. In addition, the feed system can be configured to provide either linear or circular polarization and the input impedance can be changed as well.

The VAST-12 will soon be on its first tour of duty. Meanwhile, a VAST-5.3 antenna to be based on aperture coupled dual polarized microstrip technology is currently being designed; the antenna is to operate nominally at 5.3 GHz.

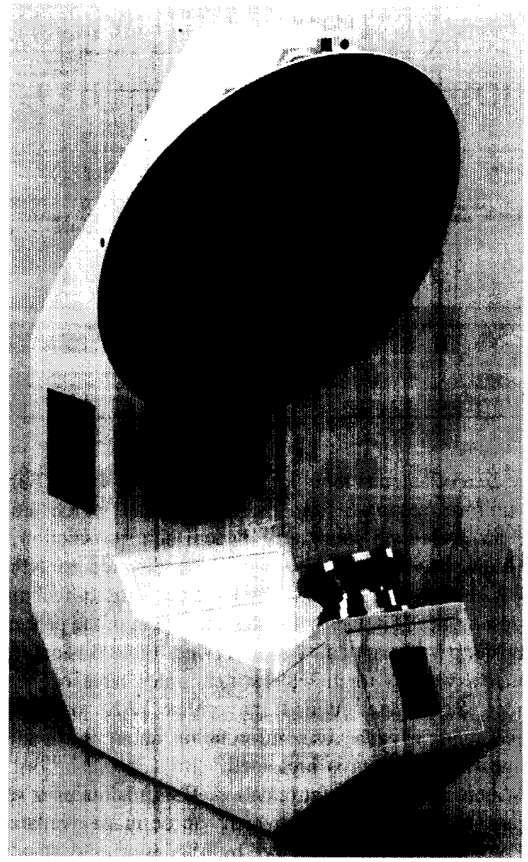

Fig. 2. Photograph of the VAST-12 antenna.

VI. Conclusion

An overview of antenna standards and laboratories in Europe has been presented both from the technical and political aspects involved. The political aspects are important in Europe due to the efforts to achieve the open single market as adopted by the EU member states. Parallel to the usual calibration services which are necessary in the fields of EMC and antenna measurements, ESA has been active in efforts to improve the overall quality of antenna measurements at those laboratories doing antenna measurements for them. A series of antennas is currently being procured in cooperation with TUD and they are working together in the definition of standardized antenna test range qualification.

Acknowledgment

In the process of collecting and collating the information presented in this paper, the author has had the pleasure of interacting with a number of persons attached to various organizations throughout Europe; to all of them, an expression of gratitude is owed. Closer to home, the Danish Telecom Telelaboratory and the Danish Institute for Fundamental Metrology were helpful in this endeavor.